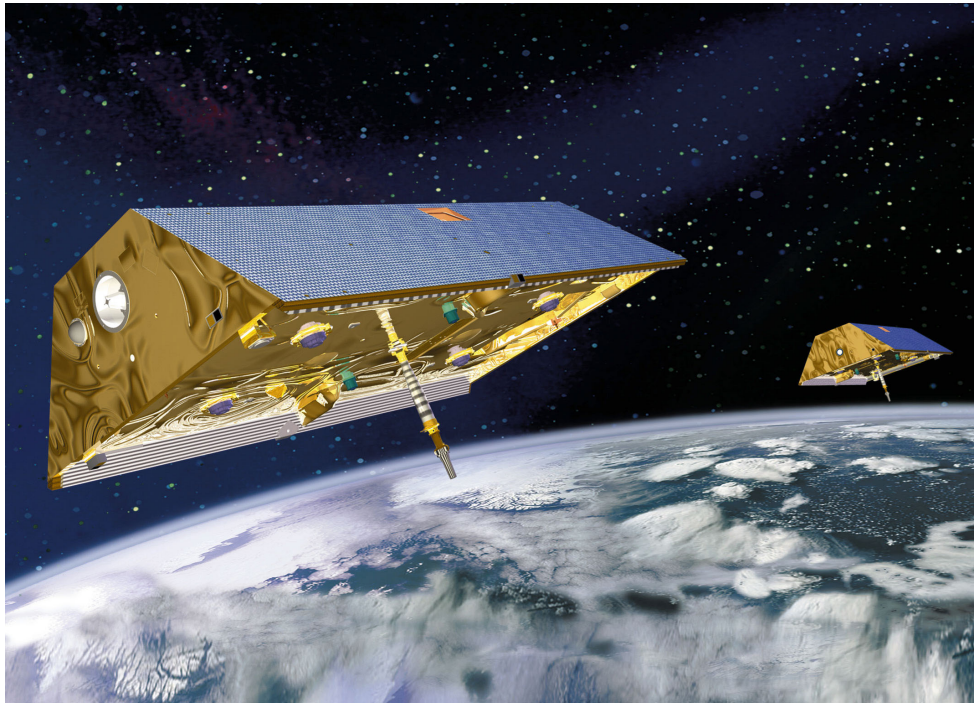
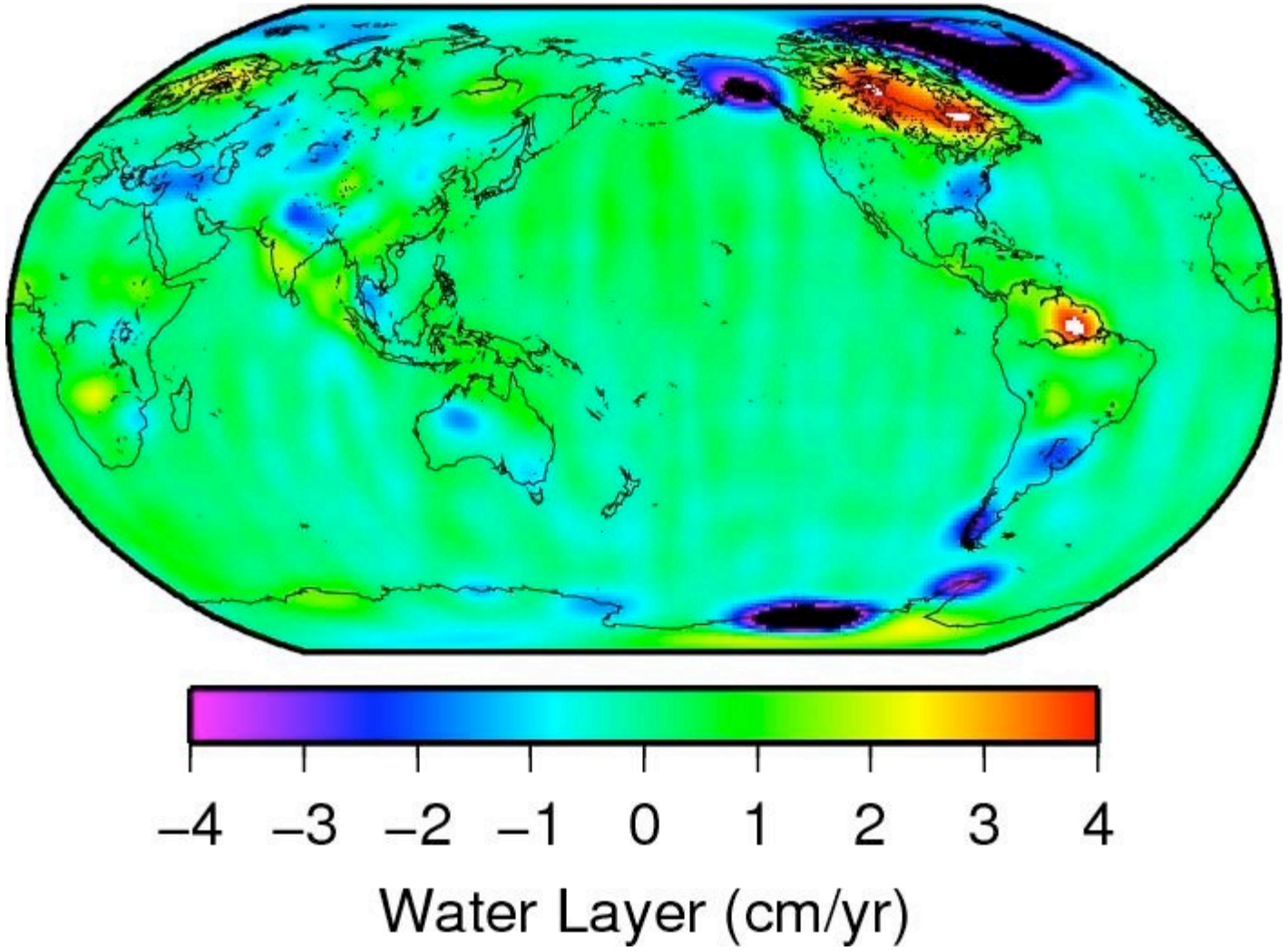
NASA DATA REVEAL MAJOR GROUNDWATER LOSS IN CALIFORNIA'S HEARTLAND



American Geophysical Union Press Conference

December 14, 2009

Trends Due to Surface Mass Variations From GRACE 2003-2009



Trends in surface mass variations as observed by the GRACE mission over the period 2003 to 2009. The bluer tones indicate areas of mass loss, while warmer red tones indicate mass gains. Units are centimeters of equivalent surface water.

GRACE - Greenland

Water Storage Changes in California's Sacramento and San Joaquin River Basins, Including Groundwater Depletion in the Central Valley

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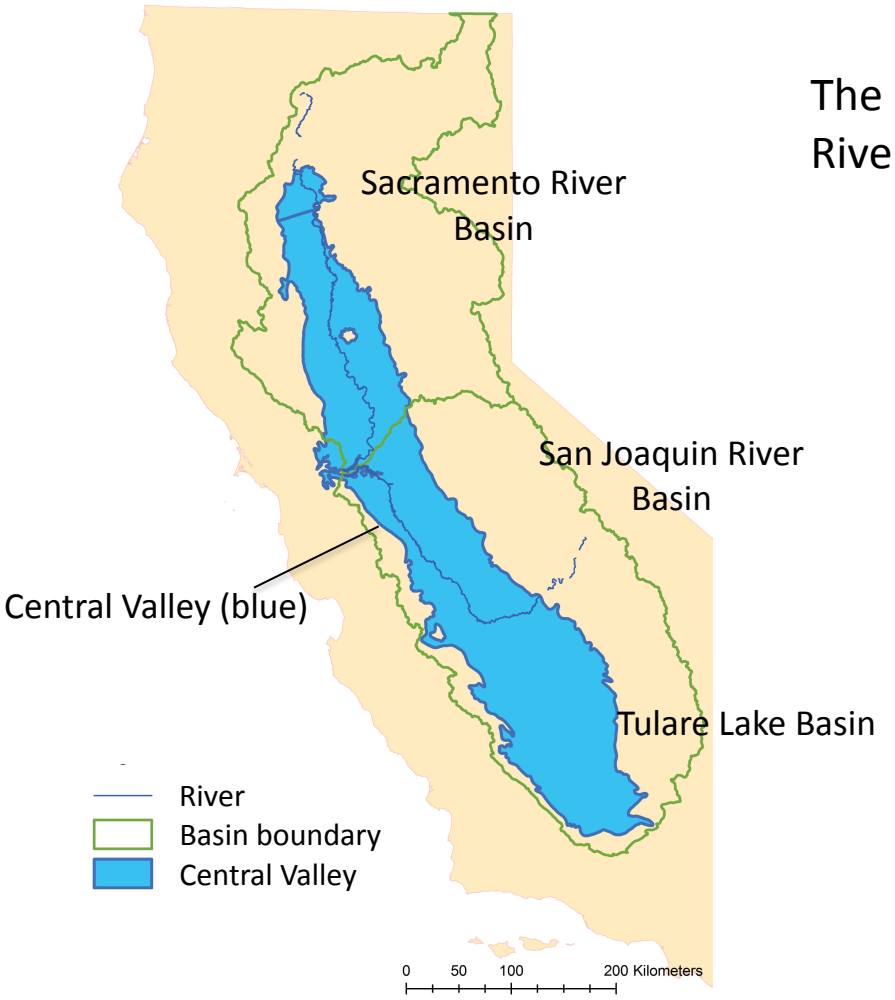
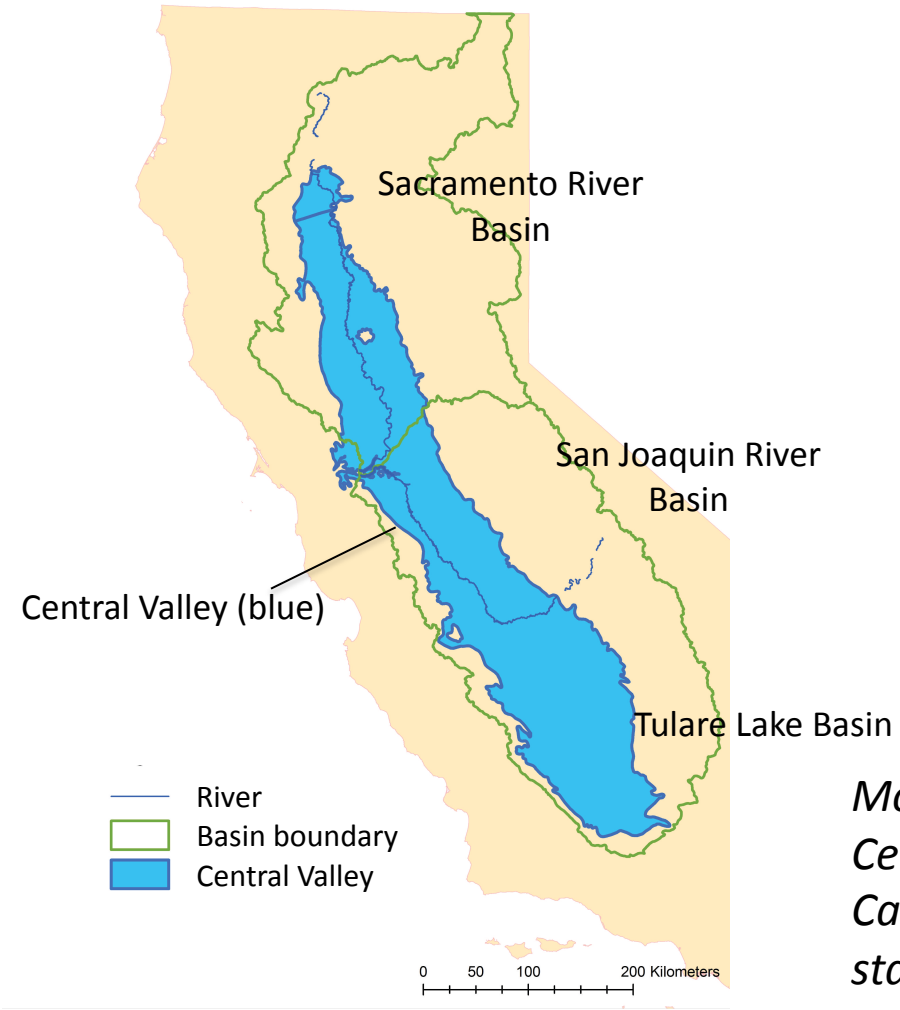


The combined Sacramento and San Joaquin River Basins

- Cover an area of approximately 154,000 km^2
- Includes California's major mountain water source, the snowpack in the Sierra Nevada mountain range
- Includes its primary agricultural region, the Central Valley (~52,000 km^2)

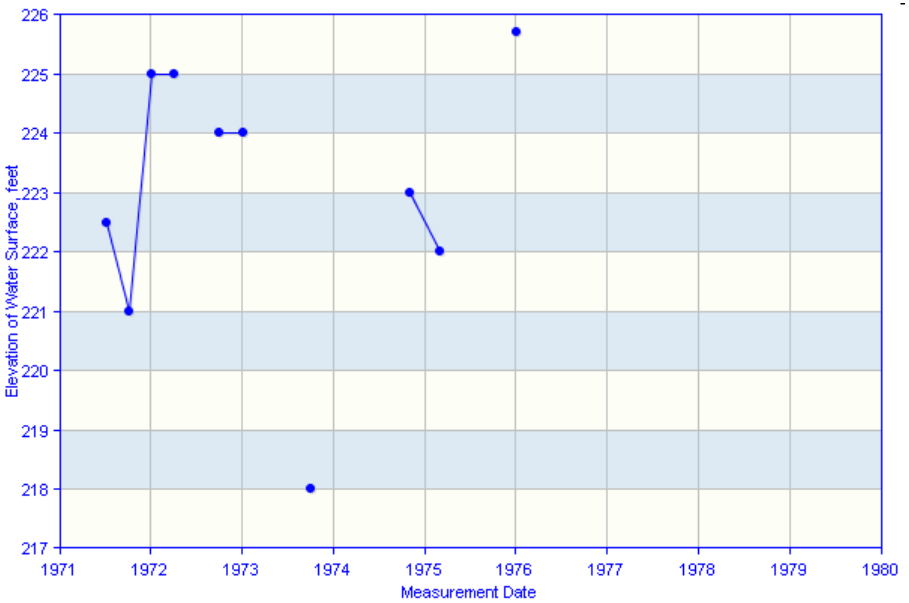
UCC HM

California's Central Valley



- Is one of the most productive agricultural regions in the world
- Produces more than 250 different crops worth $17 billion per year (2002), or 8% of the food produced in the U. S. by value
- Accounts for 1/6 of irrigated land in the U.S.
- Supplies 1/5 of the demand for groundwater in the U.S.
- Is the second most pumped aquifer in the U. S.

Monitoring groundwater availability in the Central Valley is critical to help manage California's water crisis, its impact on the state's economy and the Nation's food production



A well record from the Central Valley

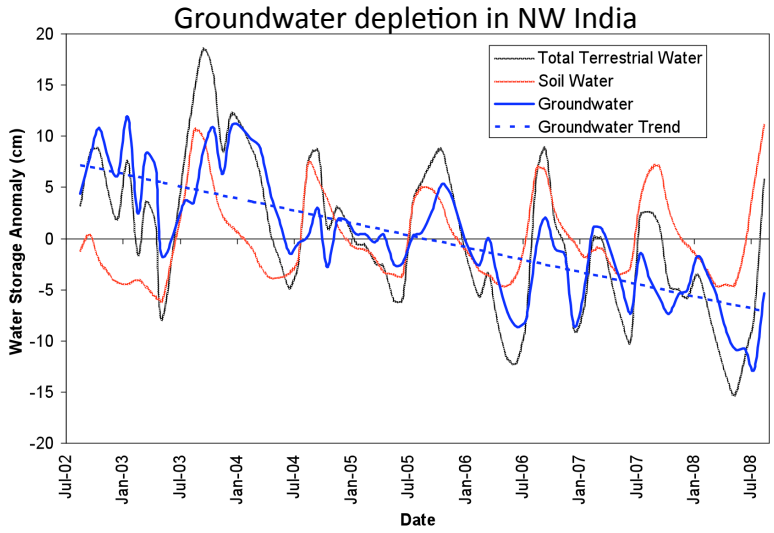
Typical groundwater monitoring relies on tracking water levels in a network of wells.

However:

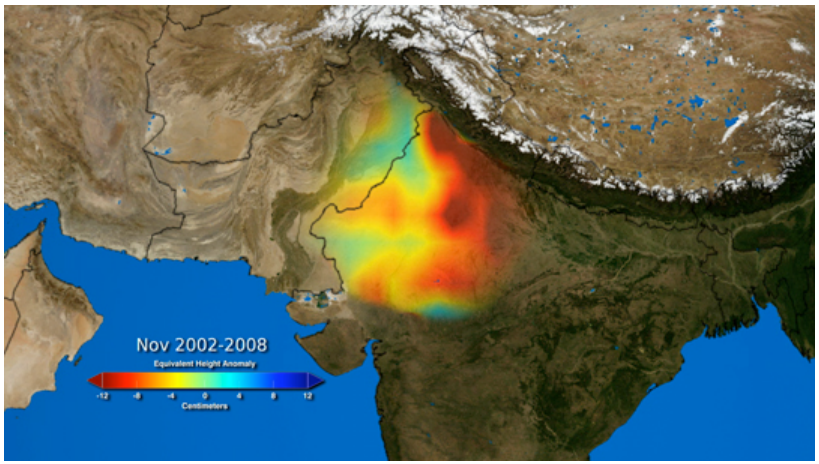
- Existing monitoring wells are sparse
- Measurement records are often discontinuous (as shown at left)
- Wells are often monitored by different agencies, at different time intervals, and record lengths often vary
- Well measurements from different local, state and federal agencies are often archived at different locations, stored in different formats, and may not be easily or freely accessible
- In short, it can be extremely difficult to compile an accurate picture of groundwater storage changes from ground-based well data alone

Data from the GRACE mission have been used in several previous studies to monitor groundwater storage changes, including those in:

- Illinois [*Yeh et al.,* 2006]
- Mississippi River Basin [*Rodell et al.*, 2007]
- High Plains Aquifer [*Strassburg et al*., 2007]
- Oklahoma [*Swenson et al.*, 2008]
- India [*Rodell et al.*, 2009, *Tiwari et al.*, 2009]



Rodell et al., 2009



Pattern of groundwater depletion in NW India

Water storage changes in the Sacramento-San Joaquin River Basins from GRACE and supplementary data, October, 2003 – March, 2009

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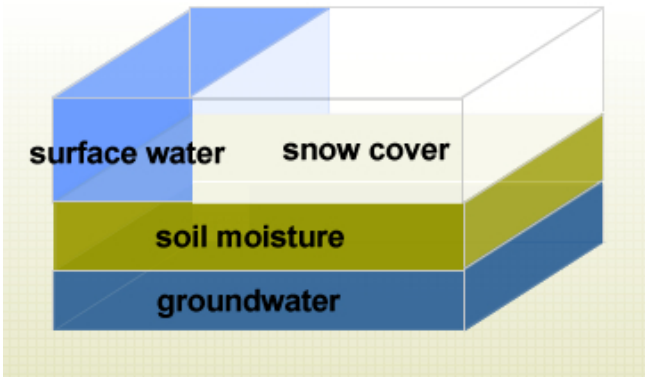
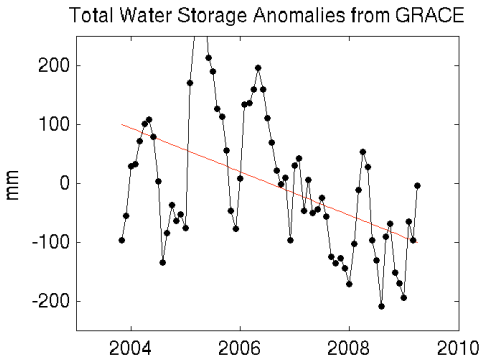
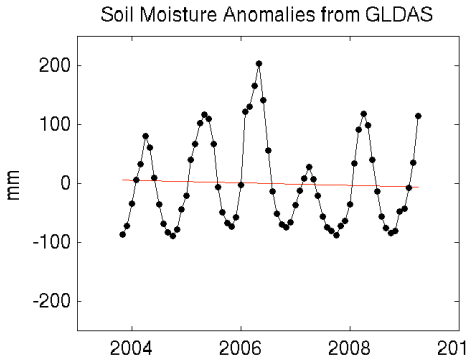
- Since GRACE 'sees' all the water storage changes on land, in order to estimate the groundwater storage change signal, the snow, surface water and soil moisture mass changes must be estimated and removed

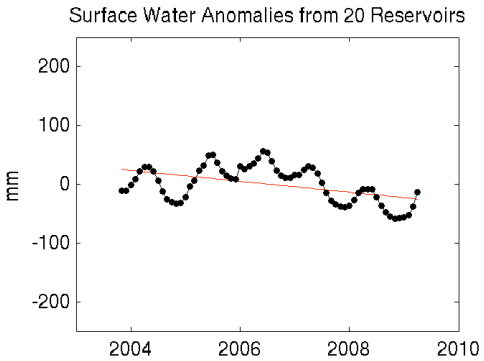
$$\Delta S_{Groundwater} = \Delta S_{Total} - \Delta S_{Snow} - \Delta S_{Surface\ Water} - \Delta S_{Soil\ Moisture}$$

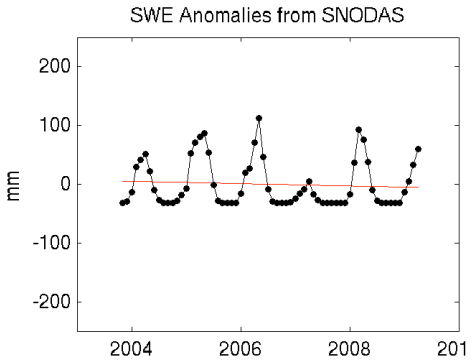
- The snow, surface water and soil moisture signals were estimated using best available observed and modeled data sets











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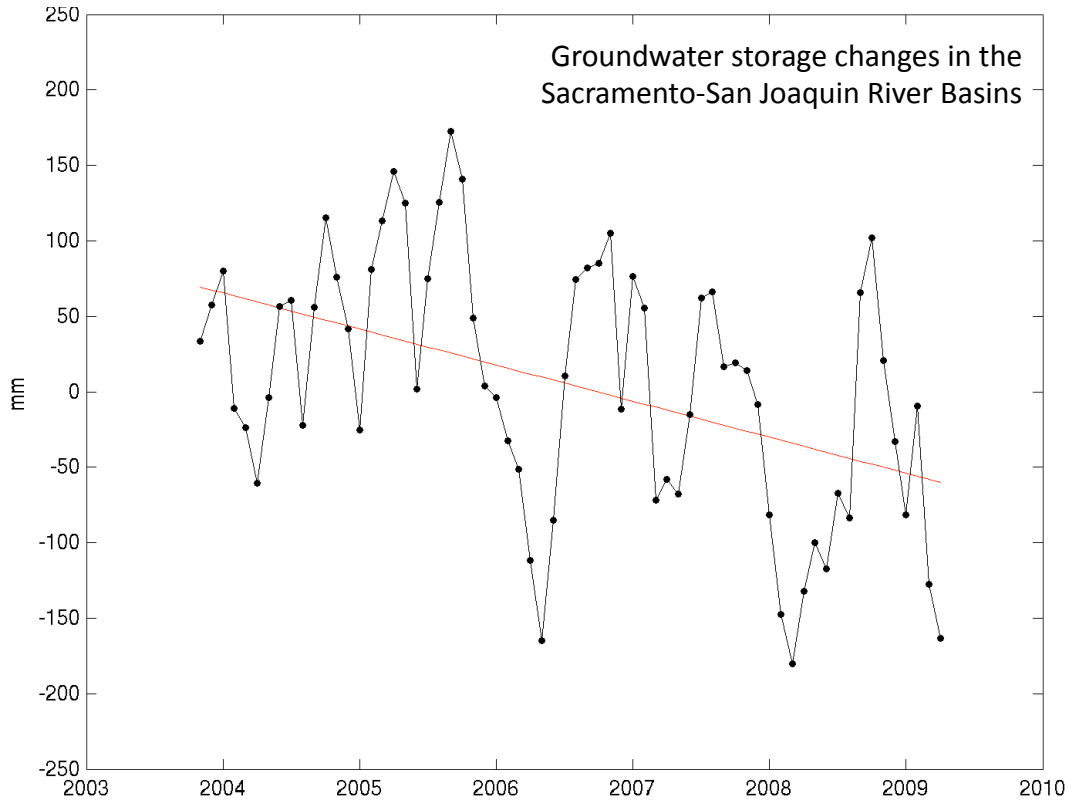
Groundwater storage changes in the Sacramento-San Joaquin River Basins from GRACE and supplementary data, October, 2003 – March, 2009



	Trend (mm/yr)	Volume lost (km^3)
GRACE Total Water Storage	-37	31.3
Snow	-2	1.7
Surface Water	-9	7.6
Soil Moisture	-2	1.7
Groundwater	-24	20.3

- In the 66 month period analyzed, the water stored in the combined Sacramento-San Joaquin River Basin decreased by over 31 km^3, or nearly the volume of Lake Mead
- Nearly two-thirds of this, or roughly 20 km^3, came from changes in groundwater storage, primarily from the Central Valley

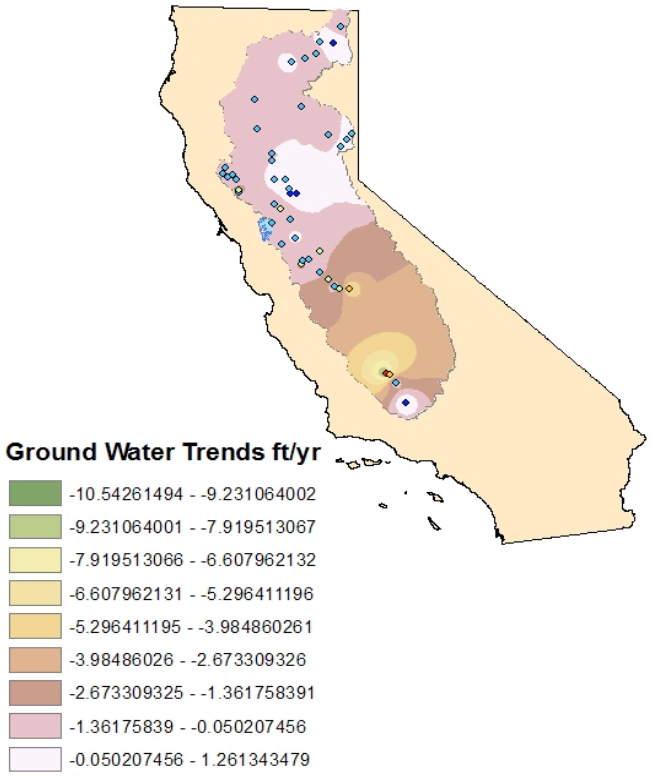
- Preliminary analyses suggest that as much as 75% of the groundwater loss is occurring in the San Joaquin River Basin, including the Tulare Lake basin, which is consistent with ground-based observations and other studies.

- Drought conditions since 2006 have minimized groundwater recharge and have resulted in constraints on surface water allocations to the Central Valley, triggering a reliance on groundwater resources, particularly in the San Joaquin Valley

- Groundwater is being used for irrigation at unsustainable rates, leading to declining water tables, decreasing crop sizes and continued land subsidence.

- In the long term, continued reliance on groundwater will deplete critical reserves that buffer cuts to surface water allocations. Continued depletions pose significant threats to food production in the U. S. and the state's economy

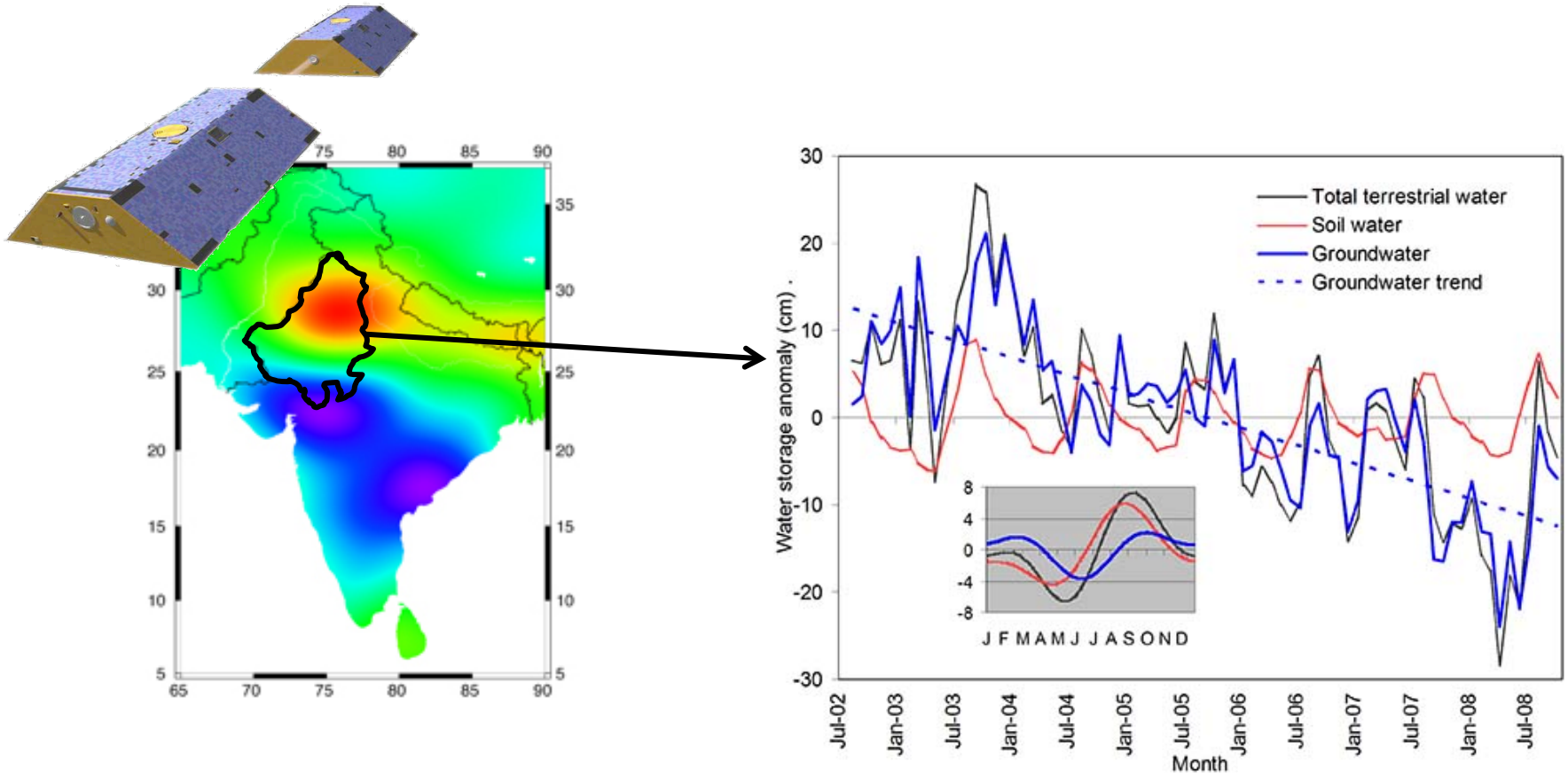
- Note that the trends are for the specified time period (October, 2003-March, 2009). This time period was selected because it maximized the overlap with the other datasets used in the study.



Observed trends in groundwater levels, October, 2003 – March, 2009

GRACE Can Monitor Human-induced Groundwater Depletion

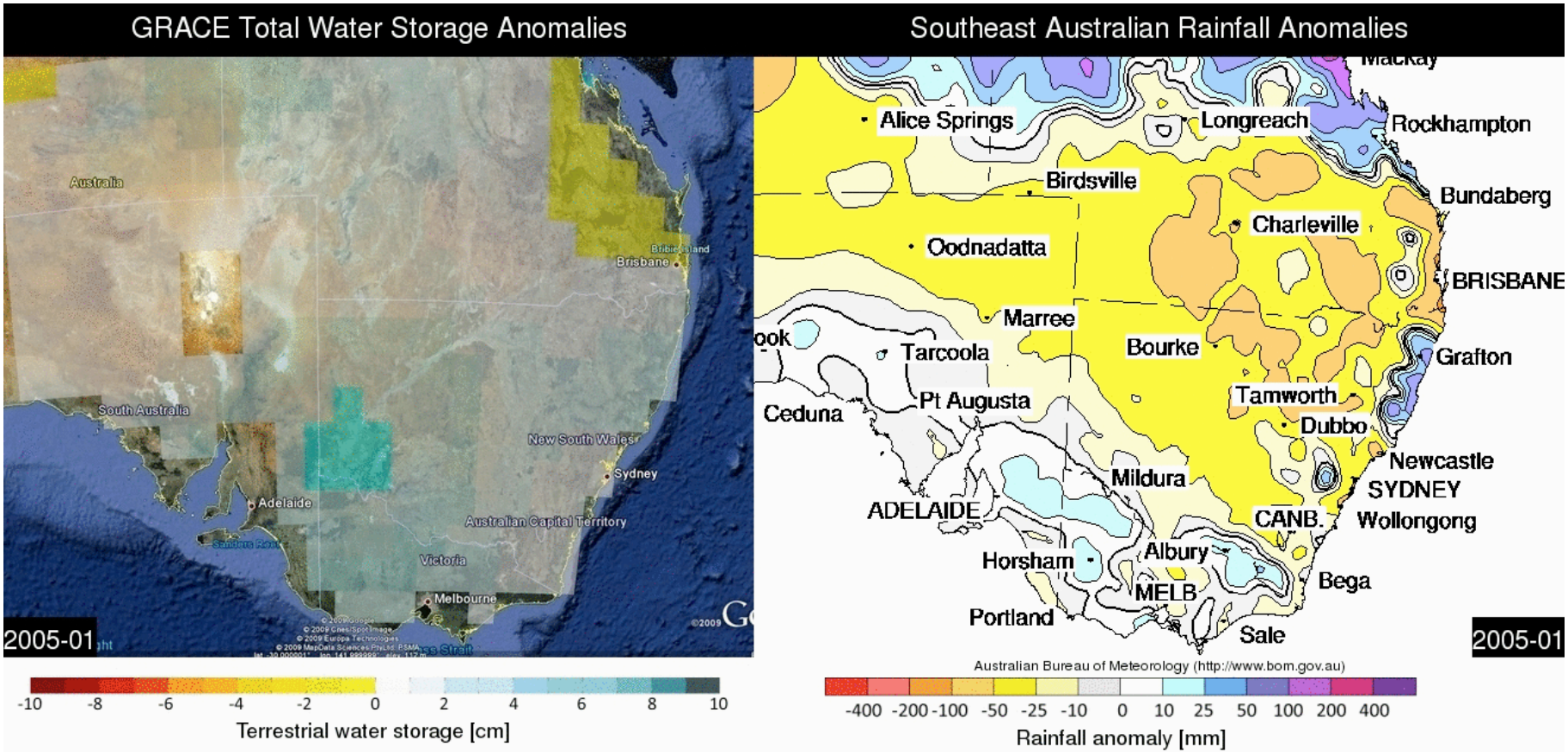
The water table in NW India is declining at an average rate of 17.7 km^3/yr



During the study period, 2002-08, 109 km^3 of groundwater was lost from the states of Rajasthan, Punjab, and Haryana; triple the capacity of Lake Mead

GRACE Satellites Provide a Unique Perspective on Drought

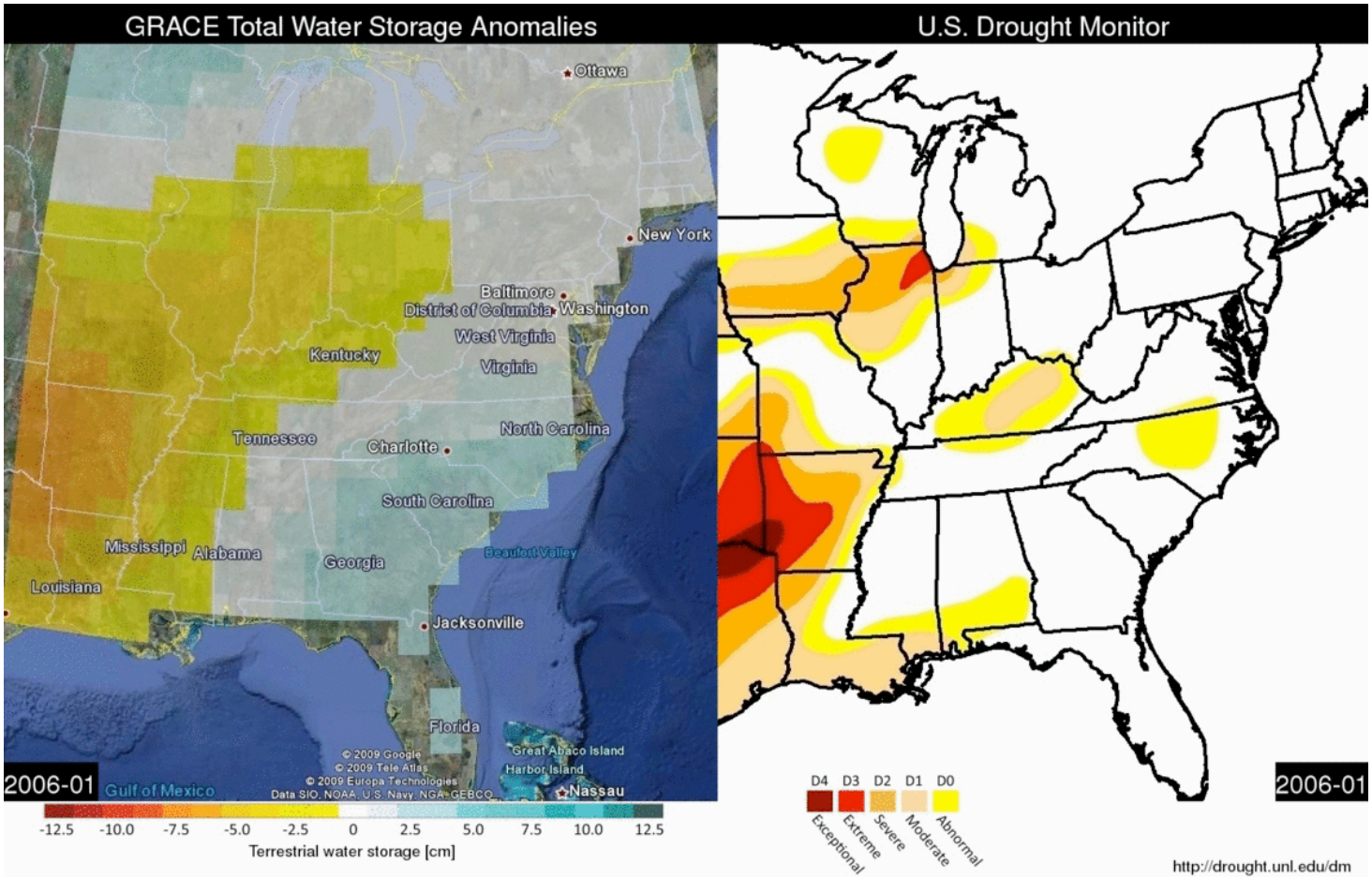
Observations reflect the cumulative effect of long-term precipitation anomalies



GRACE shows the persistence of the ongoing drought in southeastern Australia despite periodic increases in rainfall

GRACE Satellites Provide a Unique Perspective on Drought

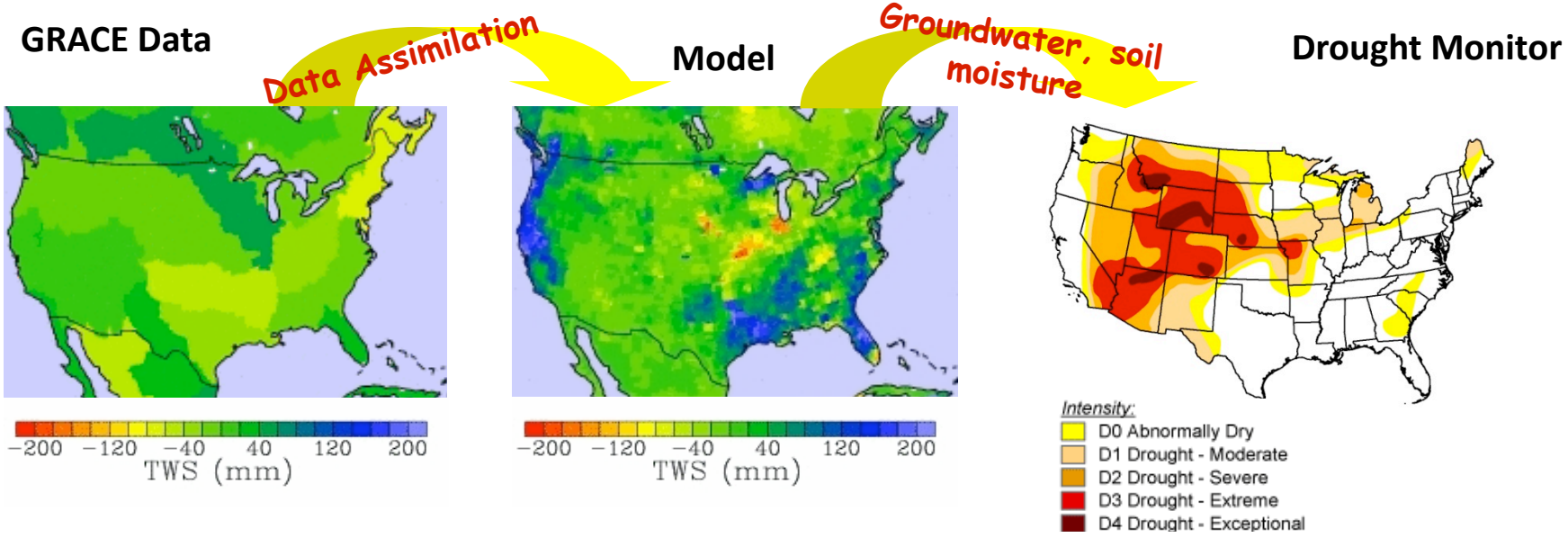
GRACE observes groundwater and deep soil moisture, key indicators of drought



GRACE captured the evolution of the 2007-08 drought in the southeastern U.S., and may soon contribute to drought monitoring and prediction

GRACE Satellites Provide a Unique Perspective on Drought

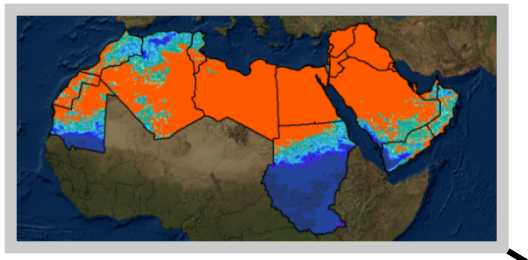
GRACE will soon contribute to drought monitoring and prediction tools



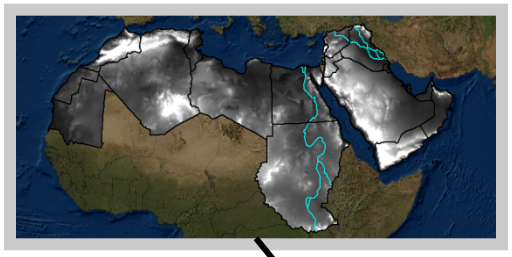
The U.S. and North American Drought Monitor products rely heavily on precipitation data and subjective reports; GRACE will improve them by providing information on deep soil moisture and groundwater

GRACE Applied to Water Resources Management

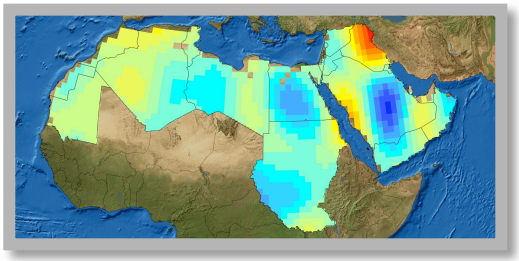
GRACE data are combined with other observations and hydrology models



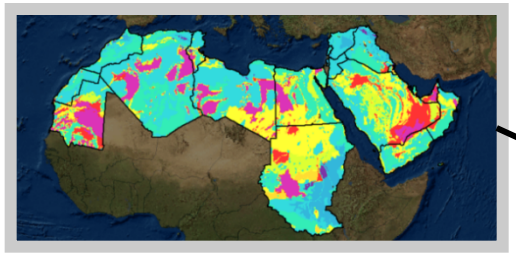
Precipitation



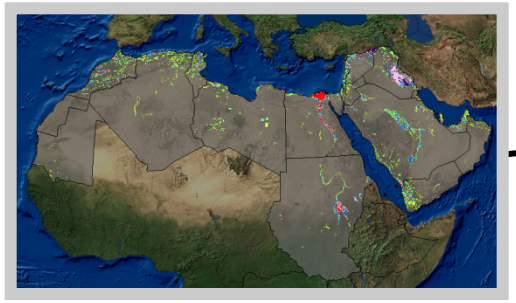
Elevation



GRACE terrestrial water storage

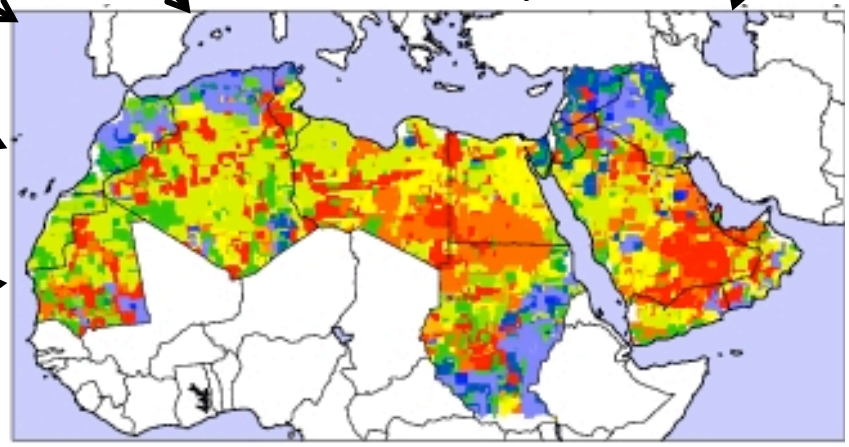


Soils



Irrigation

Water availability

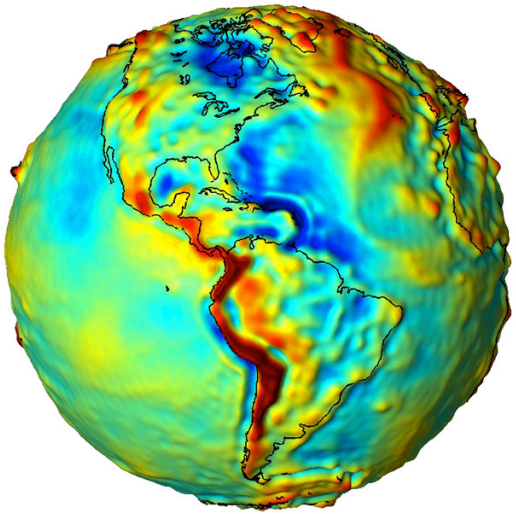


NASA, USAID, and regional partners are teaming up to improve water resources assessments and planning in the Middle East North Africa (MENA) region

GRACE web links

University of Texas Center for Space Research --
http://www.csr.utexas.edu/grace/

Jet Propulsion Laboratory –
http://grace.jpl.nasa.gov/



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